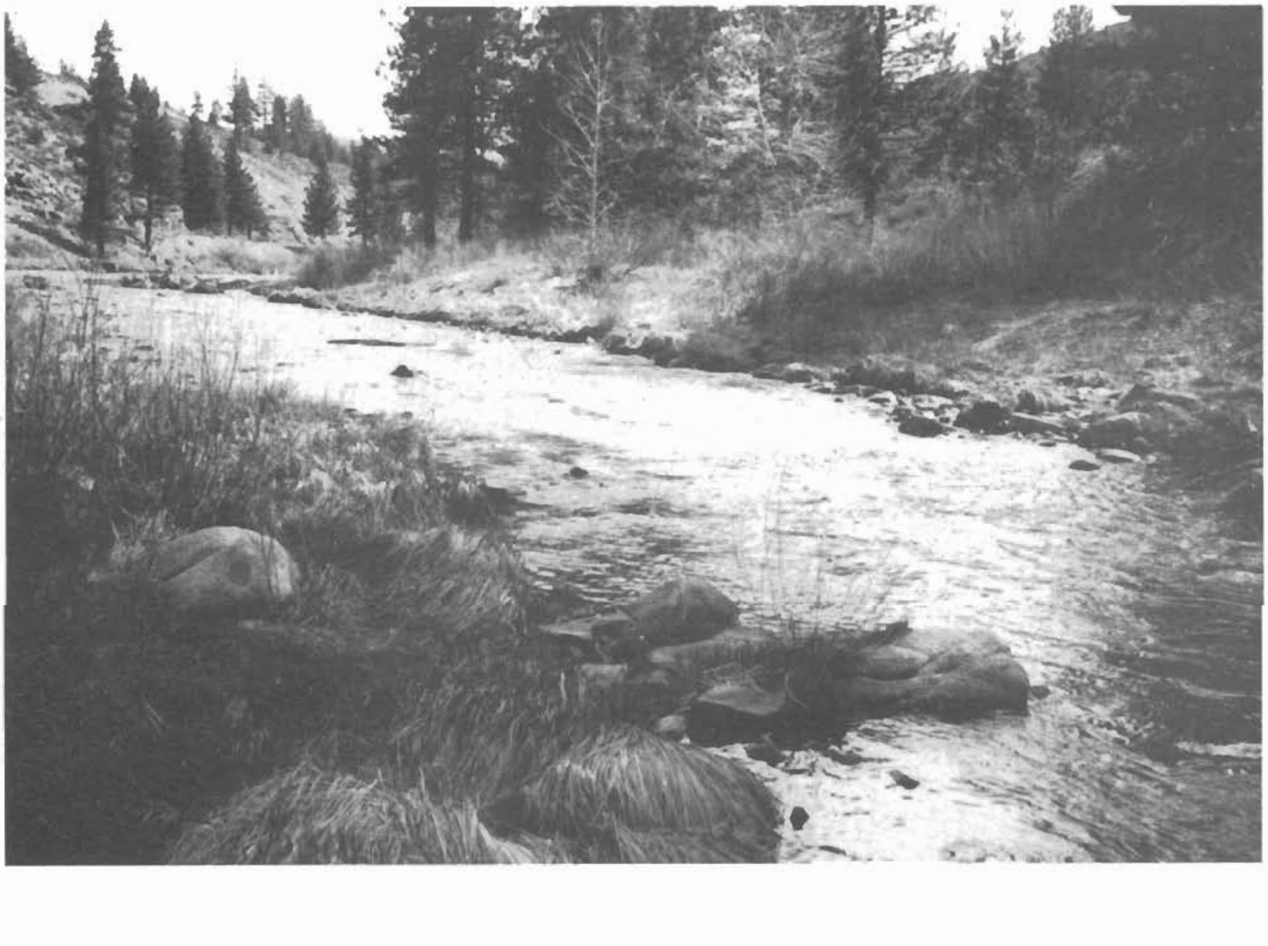
STATE OF CALIFORNIA

THE RESOURCES AGENCY

DEPARTMENT OF WATER RESOURCES

NORTHERN DISTRICT

UPPER FEATHER RIVER INSTREAM FLOW STUDY



August 1982

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FOREWORD

The Department of Water Resources built three upper Feather River reservoirs in Plumas County in the 1960s to provide public recreation and local water supply and to improve the fisheries. Antelope Reservoir was built solely for reservoir recreation and downstream fishery enhancement. Lake Davis provides these amenities and also supplies water for the city of Portola. Frenchman Reservoir provides reservoir recreation and irrigation water for Sierra Valley.

This report evaluates trout habitat in Little Last Chance Creek below Frenchman Reservoir, in Big Grizzly Creek below Lake Davis, and in the Middle Fork Feather River below the confluence with Big Grizzly Creek. Its purpose is to describe potential improvement of trout habitat and associated fishing and streamside recreation along these creeks.

Albert J. Dolcini

Albert J. Dolcini, Chief
Northern District

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SUMMARY

Three streams in the upper Feather River area were studied to determine if operation of Frenchman Reservoir and Lake Davis could be revised to improve downstream habitat conditions for trout. Study Area 1 was on Little Last Chance Creek, a tributary to the Middle Fork Feather River. Area 2 was on Big Grizzly Creek, also tributary to the Middle Fork. Area 3 was on the Middle Fork below the confluence of Big Grizzly Creek. Each area was considered representative of trout habitat in the creeks. Water depth and velocity were measured at five flows on Little Last Chance Creek, four flows on Big Grizzly Creek, and six flows on the Middle Fork.

The usable area of spawning, adult, juvenile, and fry habitat was calculated for rainbow and brown trout. Maximum usable area for spawning, juvenile, and fry habitat on Little Last Chance Creek occurred at streamflows of 0.4 to 0.8 m^3/s. Usable area for adult rainbow and brown trout habitat increased with flow on both Little Last Chance and Big Grizzly Creeks. Usable area for juvenile and fry habitat of both species on Big Grizzly Creek reached a peak near 0.4 m^3/s. Optimum flows were near 1.0 m^3/s on the Middle Fork for all habitat types except adult rainbow trout. Usable area for adult trout continued to increase with flow on the Middle Fork. No substrate suitable for spawning was present at this station.

Based on these data, a year-round release of 0.56 m^3/s was recommended from Lake Davis. This would increase trout habitat in Big Grizzly Creek, and reduce the frequency of reservoir spills, without measurably changing summer lake levels or affecting reservoir recreation.

No change in the operation schedule of Frenchman Reservoir was recommended because water rights and contracts determine the releases from the reservoir.

INTRODUCTION

This study examined whether a revised operation of Frenchman Reservoir and Lake Davis could improve habitat for brown and rainbow trout in the streams below the dams. Habitat for successive trout life history stages was examined by measuring water depth, water velocity, and substrate. Conditions for spawning pairs, adult fish, juveniles, and fry were studied to determine the flows that would provide the most habitat for each stage. If possible, streamflow releases from the reservoirs could then be modified to enhance habitat.

Frenchman Dam was built in 1961 by the Department as part of the State Water Project (Figure 1). Its purpose was to regulate Little Last Chance Creek for irrigation in the Sierra Valley and to enhance local recreation opportunities (DWR, 1957). The downstream release was intended to maintain but not enhance the stream fishery. Flood control was an incidental benefit.

The reservoir is regulated mainly to supply downstream water rights (Appendix 1). From March 15 to May 31, all inflows up to 2.7 m^3 are released to downstream diversions. All inflow is released through the dam from June 1 to October 31. The mandatory release from October 1 to March 14 is for fishery maintenance. The current maximum release for fish during this period is 0.06 m^3/s in order to fill Frenchman Reservoir by March 15, but the release may be reduced when inflow is less than 0.06 m^3/s and reservoir storage is less than 19 600 dam^3. Inflow greater than the mandatory release is stored in the reservoir from November 1 through May 31 and released later under contract. Contract water is released on demand and supplements mandatory releases. The minimum recreation pool elevation is 1 695 m except to supply fish release and water rights contracts.

Grizzly Valley Dam (Lake Davis) was also built as part of the State Water Project in 1966 (Figure 1). Originally, it was planned to supplement irrigation in Sierra Valley, but it was completed mainly to benefit recreation and the downstream fishery in Big Grizzly Creek. The reservoir also provides the water supply for the city of Portola, in Plumas County.

Operation of Grizzly Valley Dam is based on project purposes and downstream water rights (Appendix 2). Releases for recreation, fish and wildlife are based on water surface elevation on May 1. In addition to the releases for downstream fisheries and water rights, the reservoir is operated to prevent spill. This requires large releases (up to 6.65 m^3/s) in the early spring of some years.

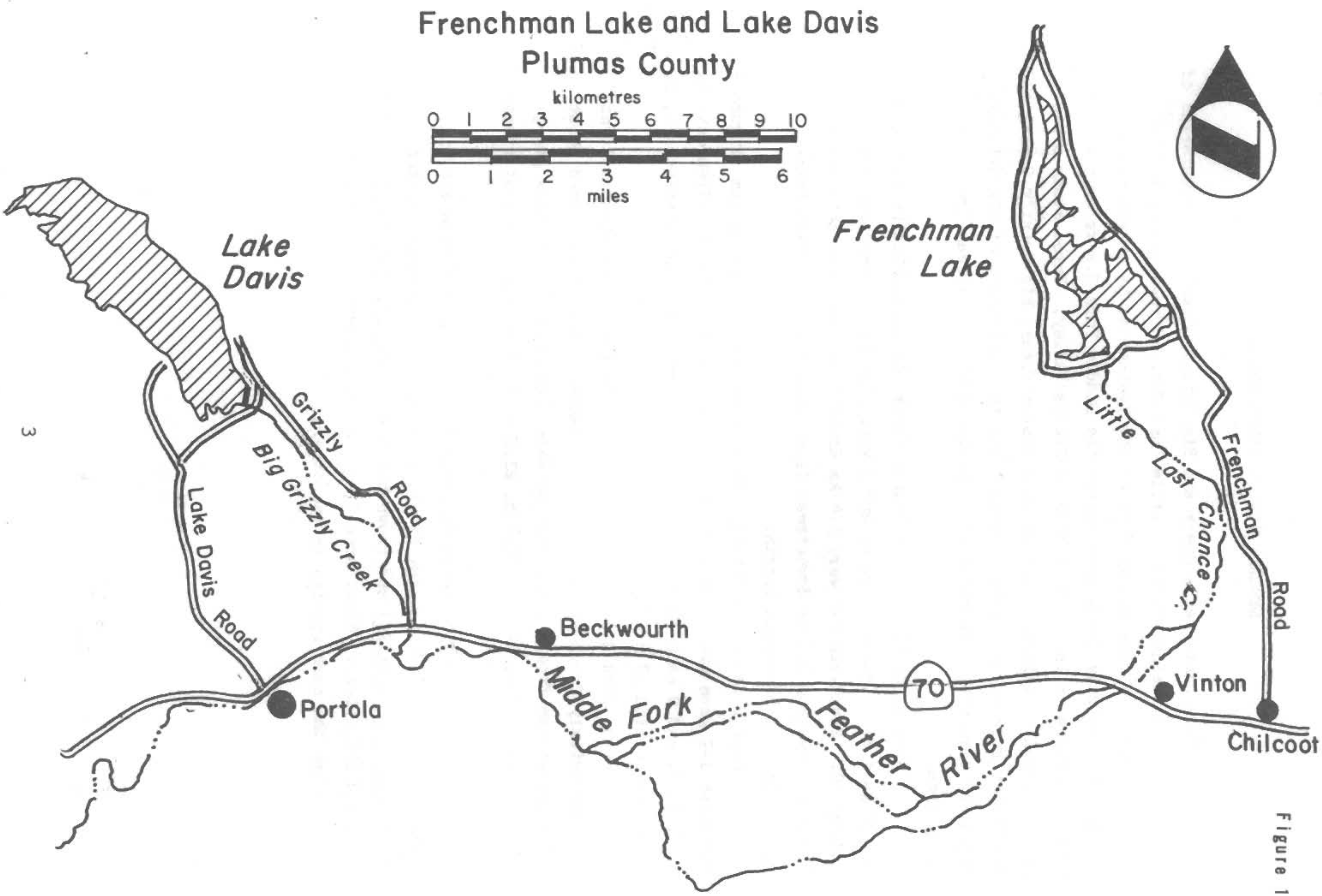

Frenchman Lake and Lake Davis
Plumas County
kilometres
0 1 2 3 4 5 6 7 8 9 10
0 1 2 3 4 5 6
miles
Lake Davis
Frenchman Lake
Grizzly Road
Big Grizzly Creek
Lake Davis Road
Portola
Beckwourth
Middle Fork Feather River
70
Vinton
Chilcoot
Little Last Chance Cr.
Frenchman Road

Figure 1

DESCRIPTION OF STUDY AREAS

Little Last Chance Creek and Big Grizzly Creek are tributaries of the Middle Fork Feather River. Little Last Chance Creek drains 210 km^2 of watershed and forms the Middle Fork of the Feather as it enters Sierra Valley. Big Grizzly Creek then enters the Middle Fork 3.2 km east of the city of Portola on the western side of Sierra Valley. Three study areas were selected to represent Little Last Chance Creek, Big Grizzly Creek, and the Middle Fork of the Feather River below the confluence of Big Grizzly. Temporary transects were established perpendicular to streamflow at each study area.

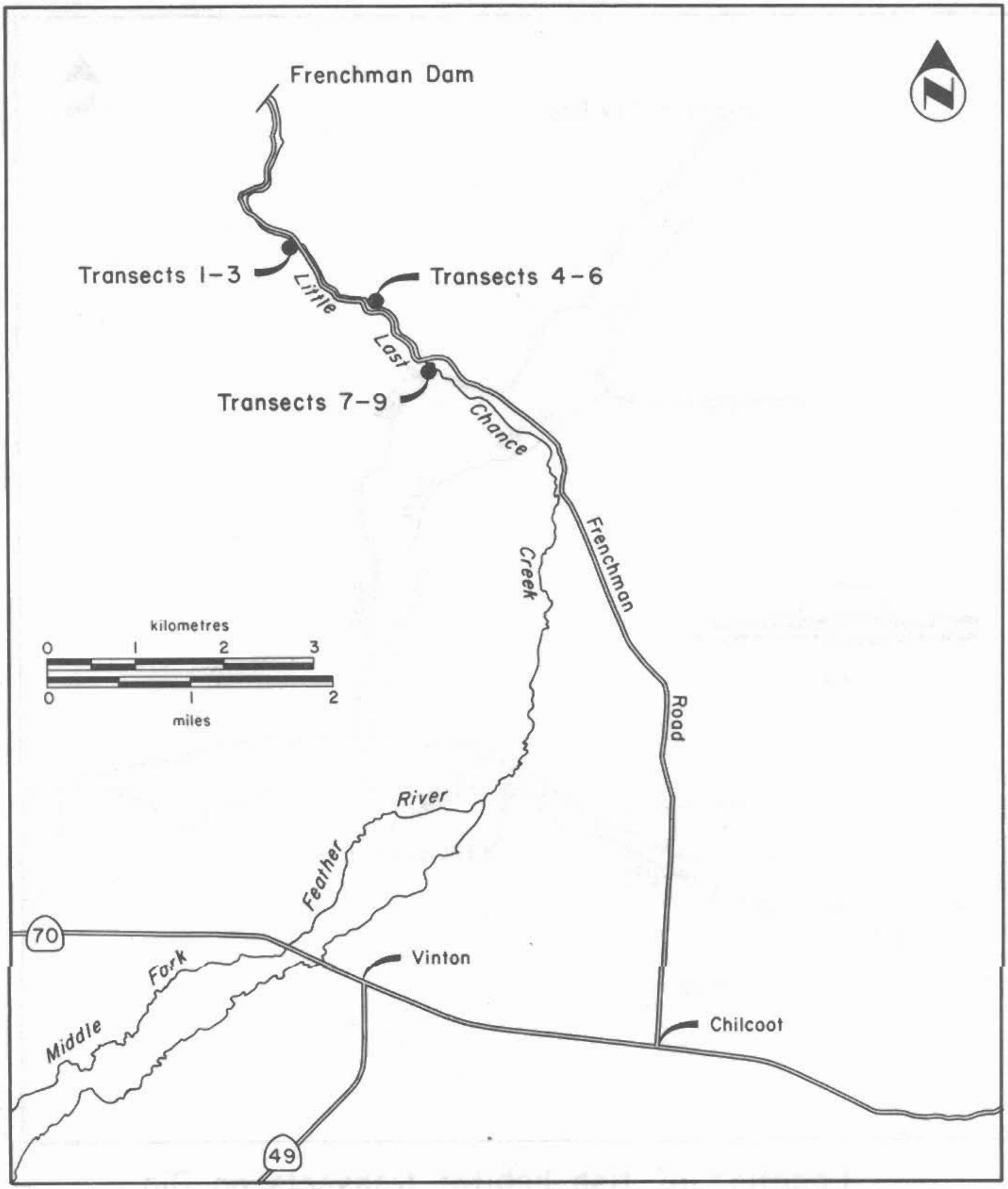
Area 1, on Little Last Chance Creek, is controlled by Frenchman Dam (Figure 2). Transects 1, 2, and 3 were 11.4 km up Frenchman Road from Highway 70. Transects 4-6 were 1.6 km downstream from Transects 1-3 and Transects 7-9 were 2.7 km downstream from Transects 1-3. Each transect represented 5 m of stream length.

Area 2 is on Big Grizzly Creek below Grizzly Valley Dam (Figure 3). Transects 1-9 were 6.6 km up Lake Davis Road from Highway 70. Transects 1, 2, 3, 7, 8, and 9 each represented 5 m of stream length and Transects 4, 5, and 6 represented 10 m of stream length.

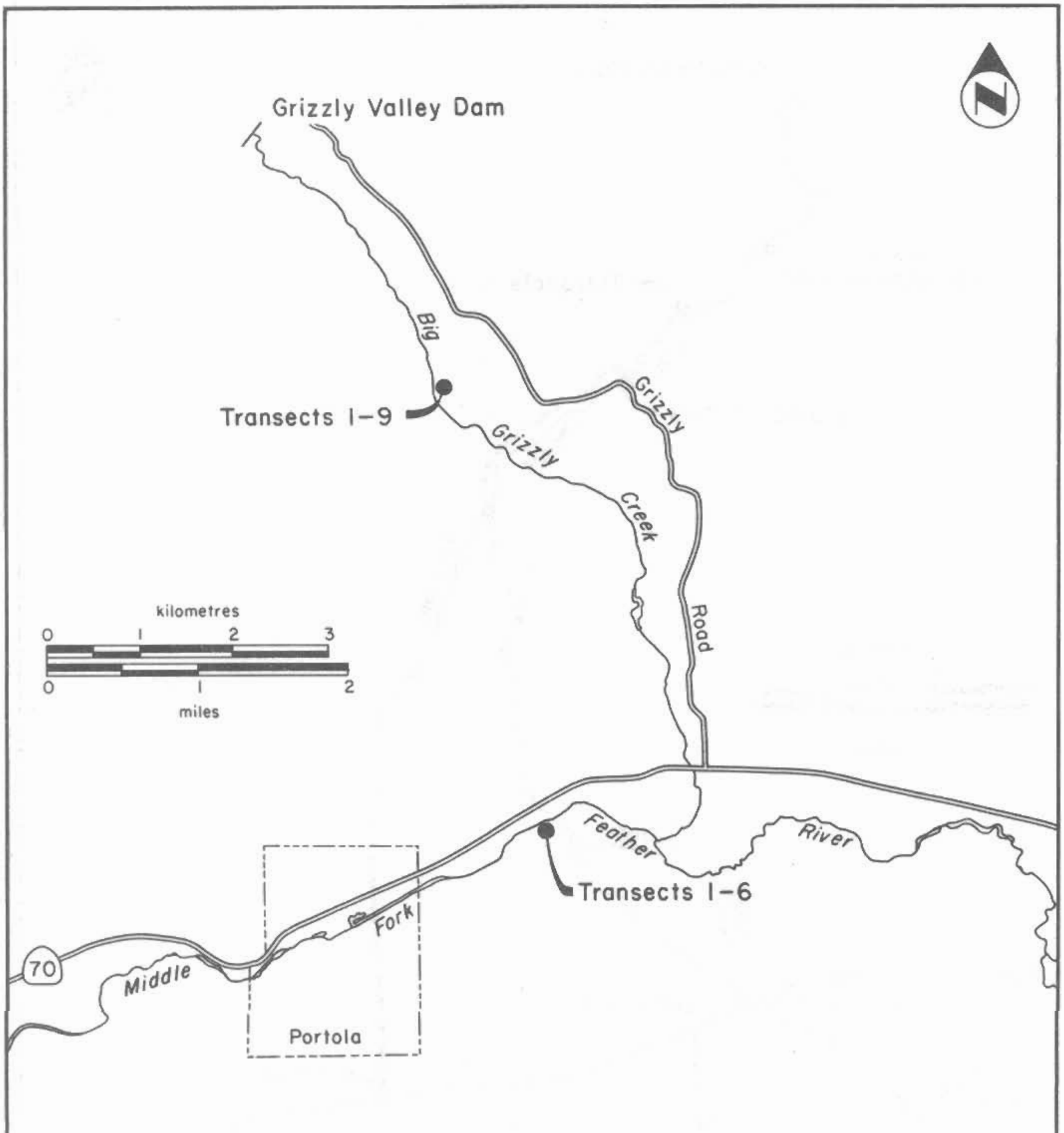
Study Area 3 is on the Middle Fork Feather below the confluence with Big Grizzly Creek (Figure 3). Six transects were established about 200 m downstream from a Department of Water Resources' streamflow gage, representing 27.1 m, 24.1 m, 22.4 m, 21.2 m, 17.1 m, and 15.1 m of stream, respectively.

Species of fish known to occur in Little Last Chance and Big Grizzly Creeks include rainbow trout, brown trout, Sacramento sucker (*Catostomus occidentalis*) and brown bullhead (*Ictalurus nebulosus*) (Brown, 1976, and DFG files). Study Area 3, on the Middle Fork Feather River, probably has the same species as the others.

Figure 2



Location of fish habitat transects on Little Last Chance Creek, Plumas County, 1981



Location of fish habitat transects on Big Grizzly Creek and Middle Fork Feather River, Plumas County, 1981

METHODS

Field Data Collection

Field data were collected using methods developed by the Federal Cooperative Instream Flow Service Group (USFWS, 1978). Wooden stakes, painted and numbered for easy identification, were used to mark transects at each study area. Total depth and mean velocity were measured across each transect with a Type AA standard current meter or a pygmy current meter. Mean velocity was measured at six-tenths of the total water depth using a metric top-reading wading rod. Water depth and velocity were measured for all flows, while substrate type was recorded at a low flow for best visibility.

Water depth and velocity were measured at Little Last Chance Creek for five flows ranging from 0.06 to 1.20 m^3/s. These parameters were measured at Big Grizzly Creek for four flows between 0.15 and 0.64 m^3/s. The Middle Fork Feather River was measured at six flows from 0.25 to 1.64 m^3/s.

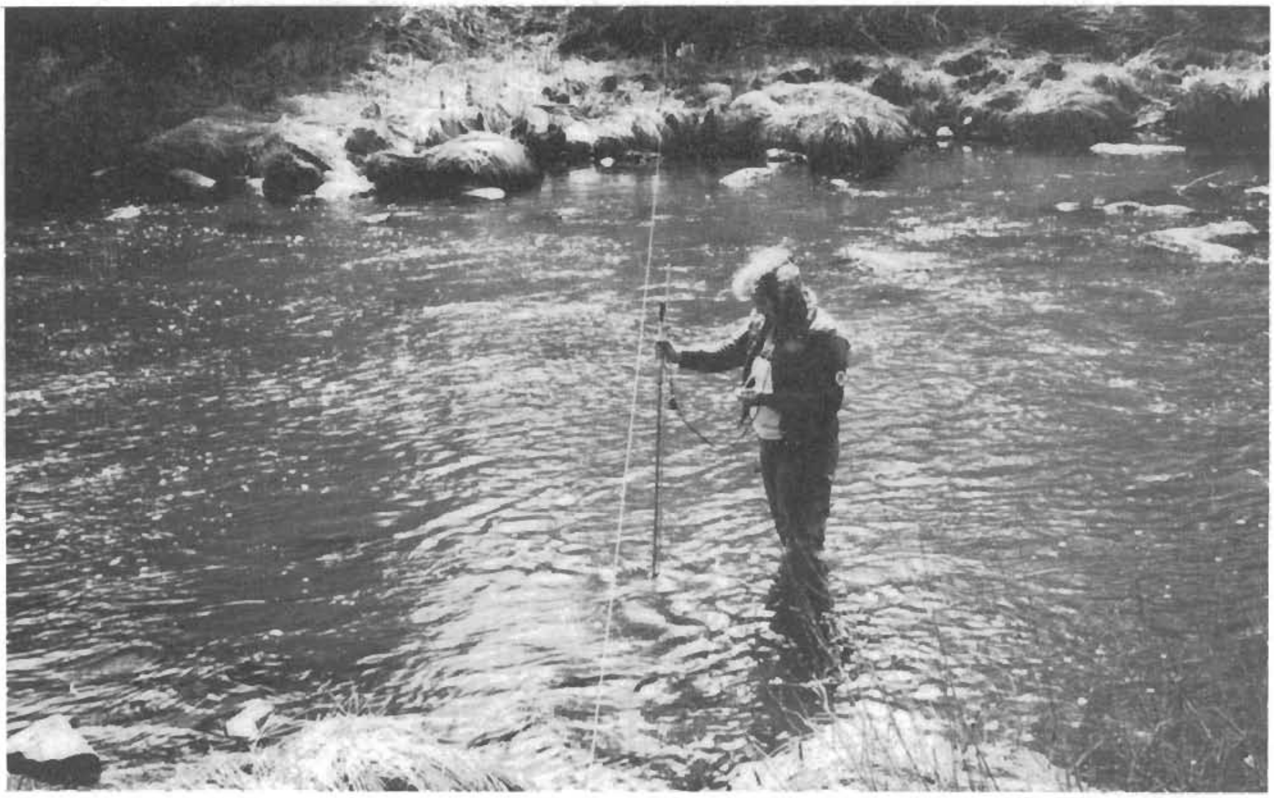


Photo: Measuring depth and velocity in the Middle Fork Feather River.

Data Analysis

Field data were analyzed by assigning a probability-of-use factor for depth, water velocity, and substrate at measured intervals along each transect (Appendix 3). The probability-of-use factor for substrate was obtained from percentages of the substrate types present. For example, in adult rainbow trout habitat, boulders have a weighting factor of 0.9 and bedrock 0.25. If 90 percent boulder substrate and 10 percent bedrock substrate were present, the final weighting factor would be: 0.90 (0.90) + 0.10 (0.25) = 0.84. The use factors for depth, water velocity, and substrate were multiplied to get a probability-of-use value for each measuring point based on the criteria for fish species and life history stage. The probability-of-use value was then multiplied by the total surface area represented by the point measured. These values were added to calculate weighted usable area for the transect and station.

Life history stages evaluated were spawning, adult, juvenile, and fry, using criteria for rainbow trout and brown trout. This information was then graphed to show relationships between streamflow and amount of habitat available for each life history stage.

RESULTS

At Study Area 1, on Little Last Chance Creek, weighted usable area for adult rainbow and brown trout habitat increased with flow (Tables 1 and 2). Weighted usable area for rainbow trout spawning and juvenile habitat also increased with flow. Maximum weighted usable area for rainbow trout fry occurred at 0.44 m^3/s. Maximum brown trout spawning habitat occurred at 0.74 m^3/s while maximum juvenile and fry habitat was at 0.44 m^3/s. Optimum usable area for all habitat types for both species occurred at flows ranging from 0.4 to 0.8 m^3/s (Figures 4 and 5).

At Study Area 2, on Big Grizzly Creek, weighted usable area for adult rainbow and brown trout also increased with flow (Tables 3 and 4). Weighted usable area for rainbow and brown trout juveniles and fry was highest near 0.42 m^3/s (Figures 6 and 7). There was no usable area for spawning at the flows we measured at this study area.

Considerably more usable area was available at Study Area 3, on the Middle Fork Feather River, compared to Little Last Chance, and Big Grizzly Creeks (Tables 5 and 6). Maximum weighted usable area was near 1.0 m^3/s for rainbow and brown trout fry and juveniles. Rainbow trout adult habitat increased with flow up to 1.64 m^3/s, while adult habitat for brown trout peaked at 1.3 m^3/s. No substrate suitable for spawning was found at this study area.

TABLE 1. WEIGHTED USABLE AREA (m^2) FOR RAINBOW TROUT IN LITTLE LAST CHANCE CREEK, 1981

	Life History Stage			
Flow (m^3/s)	Spawning	Adult	Juvenile	Fry
0.06	0.5	7.3	3.4	6.6
0.19	2.2	14.1	8.2	10.4
0.44	5.3	31.9	16.3	15.4
0.74	9.4	35.7	17.4	15.3
1.20	9.6	45.9	18.3	14.4

TABLE 2. WEIGHTED USABLE AREA (m^2) FOR BROWN TROUT IN LITTLE LAST CHANCE CREEK, 1981

	Life History Stage			
Flow (m^3/s)	Spawning	Adult	Juvenile	Fry
0.06	1.0	6.5	25.4	33.1
0.19	2.4	7.0	28.0	39.4
0.44	6.1	13.8	35.8	50.3
0.74	9.2	14.5	35.5	49.7
1.2	8.1	17.9	30.9	43.9

TABLE 3. WEIGHTED USABLE AREA (m^2) FOR RAINBOW TROUT IN BIG GRIZZLY CREEK, 1981

	Life History Stage			
Flow (m^3/s)	Spawning	Adult	Juvenile	Fry
0.15	0	18.4	5.7	7.8
0.24	0	22.5	6.7	8.8
0.42	0	33.7	8.1	9.6
0.64	0	46.1	7.2	8.9

TABLE 4. WEIGHTED USABLE AREA (m^2) FOR BROWN TROUT IN BIG GRIZZLY CREEK, 1981

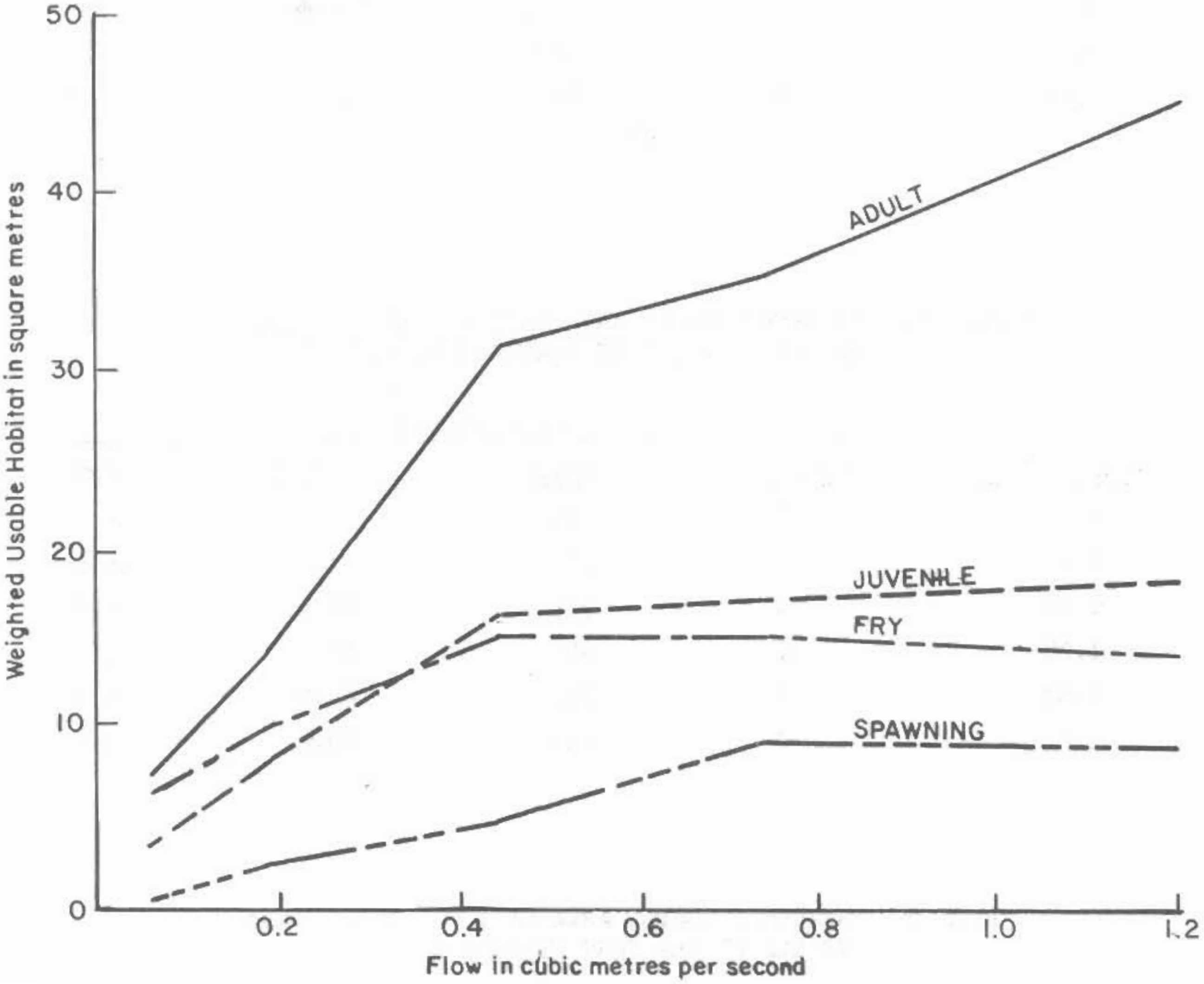
	Life History Stage			
Flow (m^3/s)	Spawning	Adult	Juvenile	Fry
0.15	0	26.3	52.9	72.8
0.24	0	32.5	52.2	73.8
0.42	0	33.9	54.7	78.4
0.64	0	44.7	54.2	78.2

TABLE 5. WEIGHTED USABLE AREA (m^2) FOR RAINBOW TROUT IN THE MIDDLE FORK FEATHER RIVER, 1981

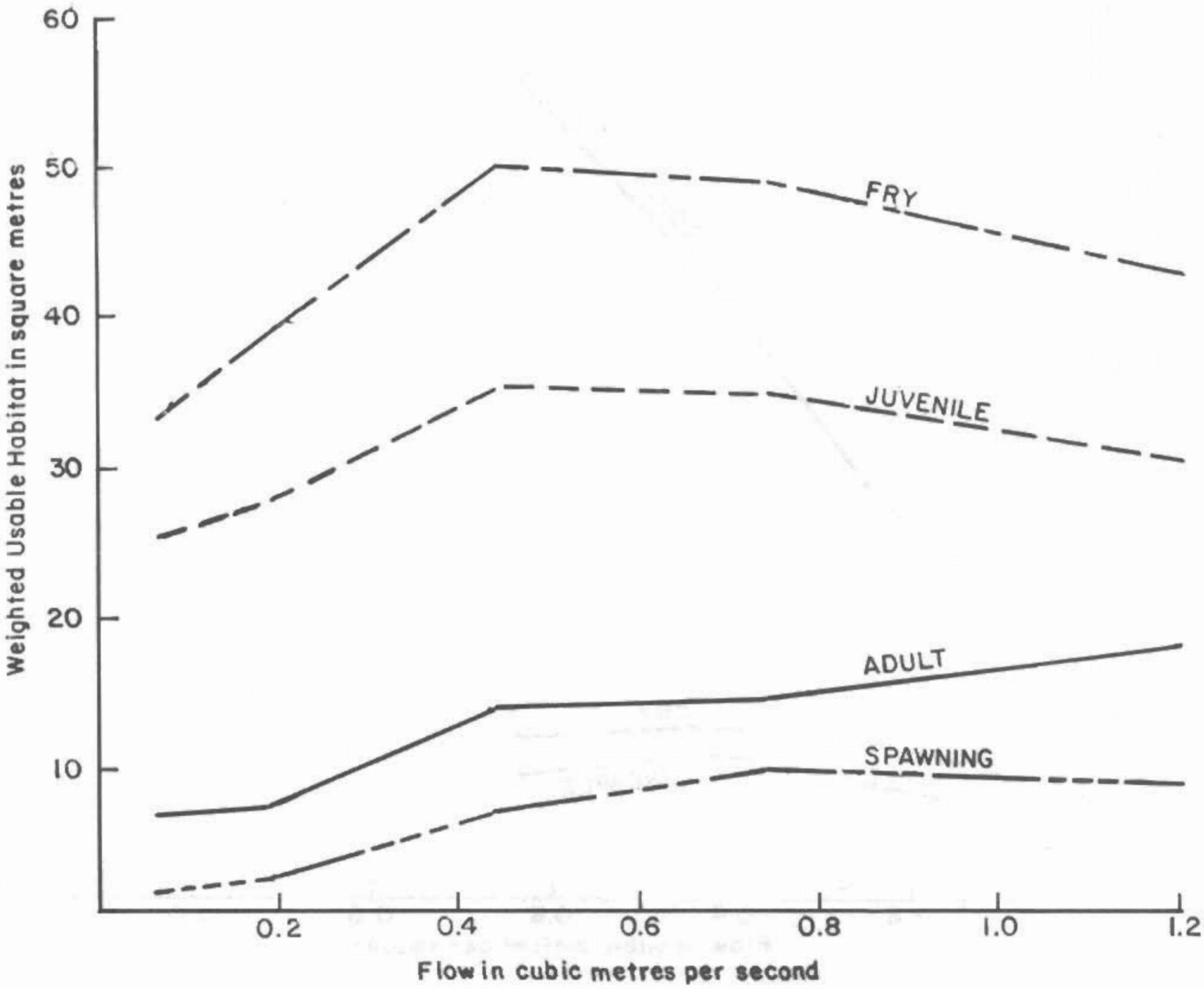
	Life History Stage			
Flow (m^3/s)	Spawning	Adult	Juvenile	Fry
0.25	0	99	33.1	50.8
0.41	0	123	43.8	56.2
0.78	0	225	69.6	68.9
1.02	0	314	85.3	73.2
1.30	0	377	84.0	65.9
1.64	0	438	80.0	56.8

TABLE 6. WEIGHTED USABLE AREA (m^2) FOR BROWN TROUT IN THE MIDDLE FORK FEATHER RIVER, 1981

	Life History Stage			
Flow (m^3/s)	Spawning	Adult	Juvenile	Fry
0.25	0	120	299	403
0.41	0	133	288	391
0.78	0	169	322	445
1.02	0	217	373	498
1.30	0	226	359	479
1.64	0	220	327	440

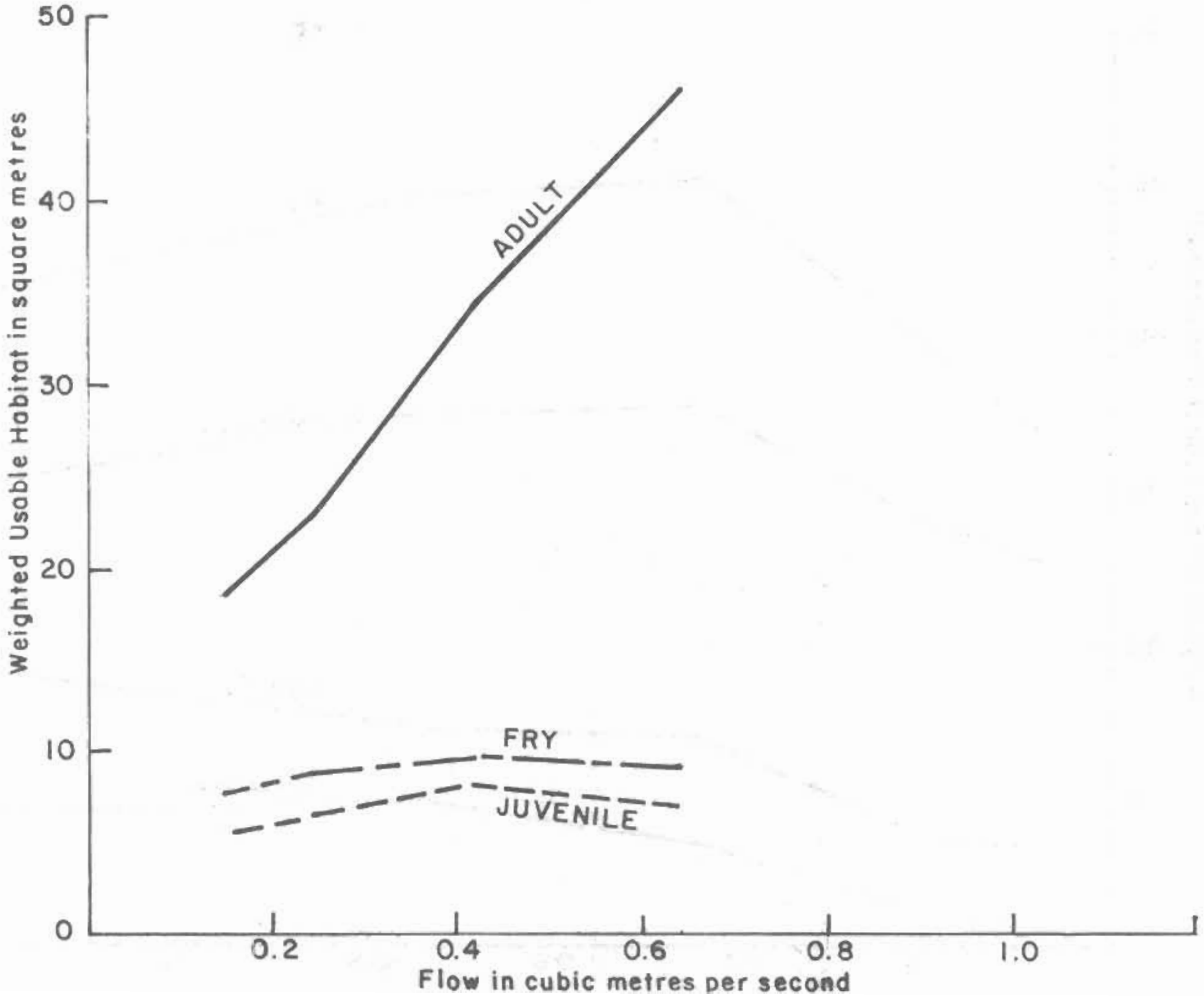


Relationship of rainbow trout habitat and flow for four life history stages, Little Last Chance Creek, Plumas County, 1981

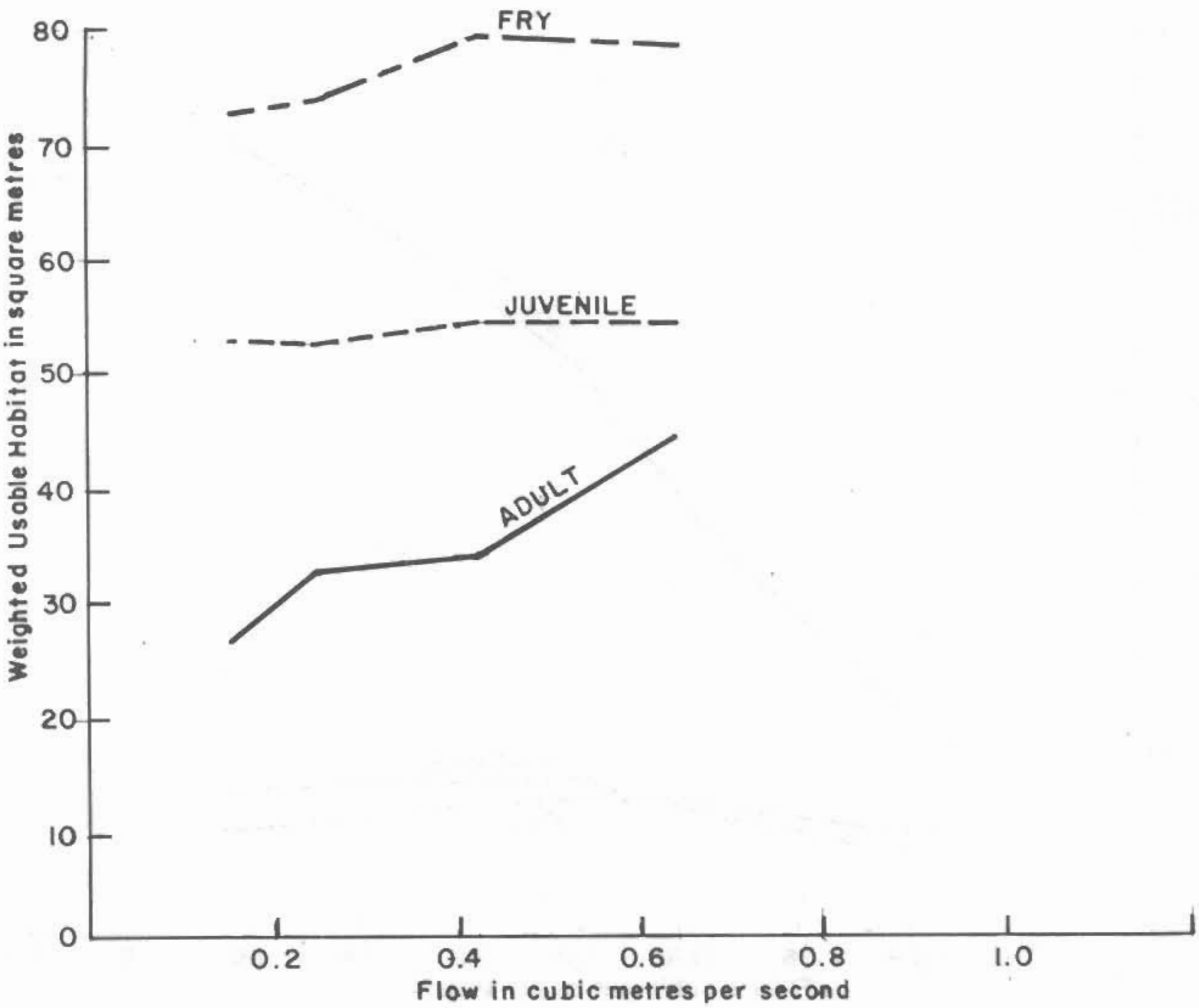


Relationship of brown trout habitat and flow for four life history stages, Little Last Chance Creek, Plumas County, 1981.

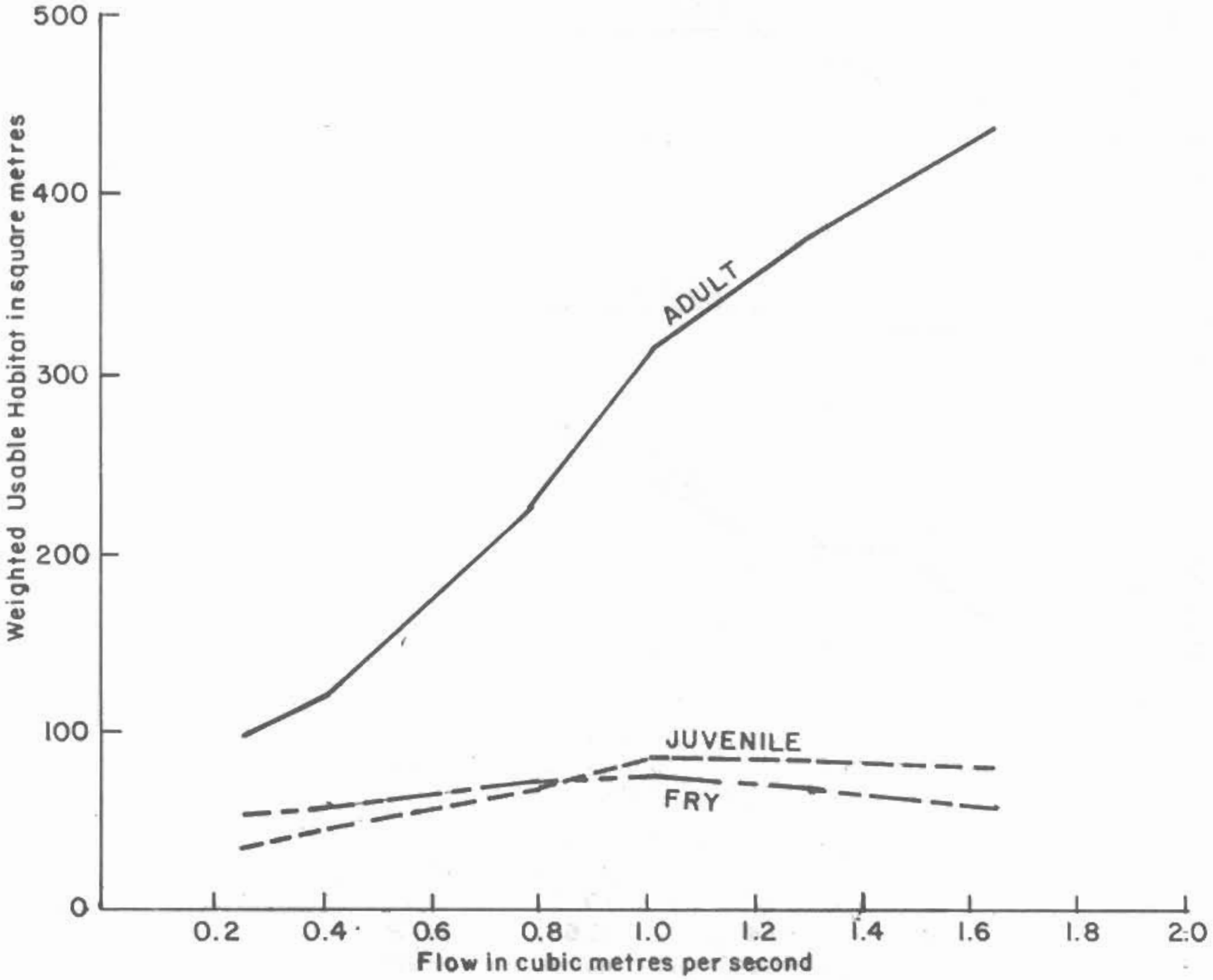
Figure 6



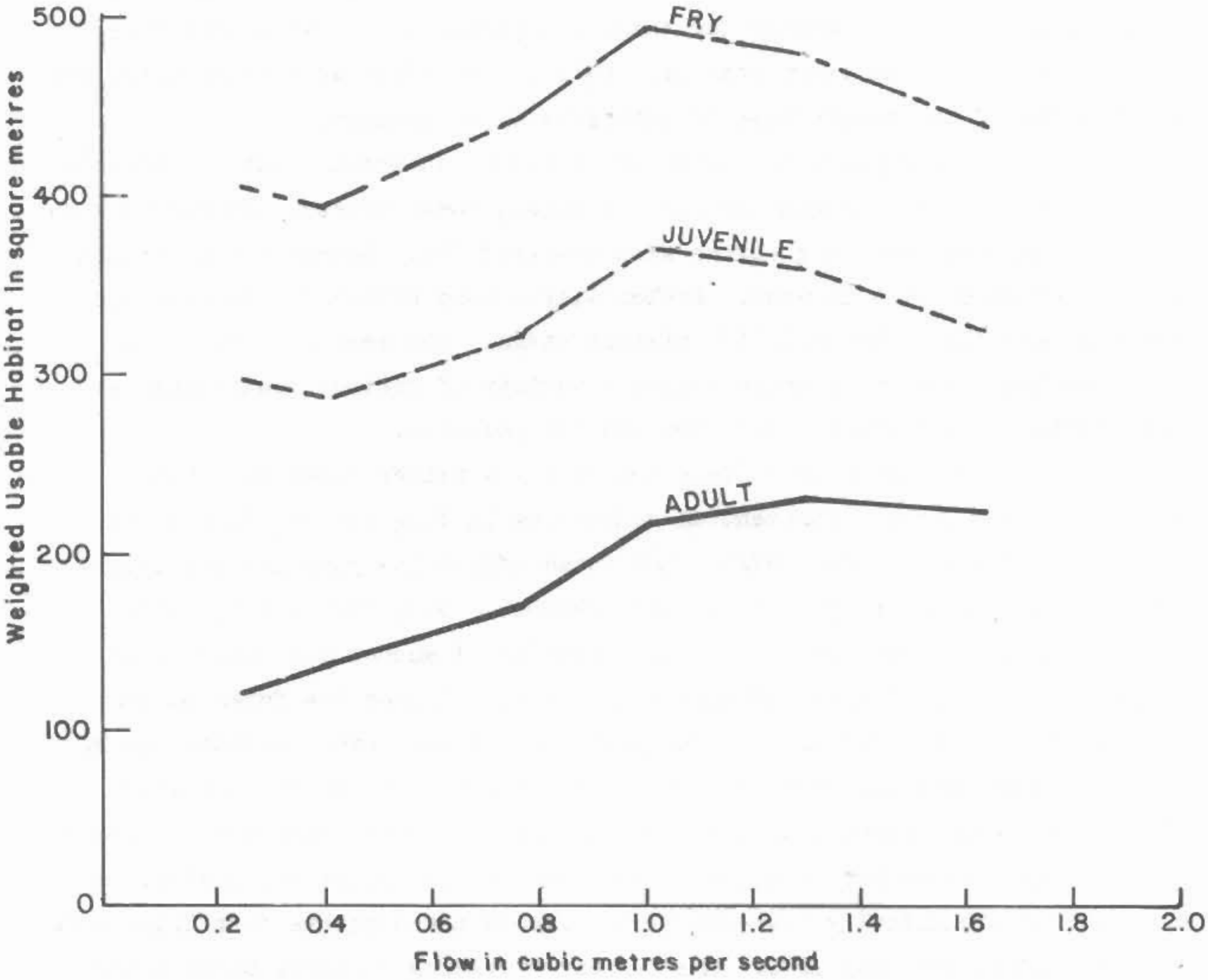
Relationship of rainbow trout habitat and flow for three life history stages, Big Grizzly Creek, Plumas County, 1981.



Relationship of brown trout habitat and flow for three life history stages, Big Grizzly Creek, Plumas County, 1981.



Relationship of rainbow trout habitat and flow for three life history stages, Middle Fork Feather River, Plumas County, 1981



Relationship of brown trout habitat and flow for three life history stages, Middle Fork Feather River, Plumas County, 1981.

DISCUSSION

Generally, data were collected using the Federal Instream Flow Service Group methods. The substrate weighting method was modified to reflect the type of streams studied. The federal method of weighting does not allow for substrates that do not follow a continuum, i.e. boulders and sand together. To compensate for this, the percentage of each substrate type was estimated at every measuring point. The final weighting factor was a composite of the percentages of substrate types present.

Probability-of-use curves for rainbow and brown trout egg incubation are part of the federal method. However, these streams had slopes much steeper than the available curves were designed for. Consequently, incubation flows were not evaluated. Probability-of-use curves for temperature are also available for each life history stage. Our measurements on the upper Feather River were taken during a variety of weather conditions, so correlation of temperature and flow was not possible.

Little Last Chance Creek has very low winter flows and high, erratic summer flows. Substantial reductions in flow are detrimental to trout populations (Kraft, 1972). Low flows affect the physical parameters of depth and velocity by reducing both (Wesche, 1973, and Curtis, 1959). Very low winter flows can also allow formation of anchor ice that may be damaging to trout (Butler and Hawthorne, 1979). Anchor ice forms on the bottom of streams, generally during periods of clear skies, accompanied by freezing temperatures, often following long periods of low precipitation. These are common winter conditions in the upper Feather River area. Anchor ice is very destructive to aquatic life, and, if it occurs frequently, can keep stream productivity low even if the stream has adequate fertility, cover, and streamflow for fish life. The current operating criteria allow a maximum of 0.06 m^3/s during the winter months and less during dry years. Higher flows during the winter months would be beneficial to fish populations. Study also shows that flows above 0.8 m^3/s reduce available brown trout spawning, juvenile, and fry habitat. Current summer releases are highly variable, with flows ranging from above 2.8 m^3/s to 0.28 m^3/s and below. An arrangement with water users to minimize fluctuations in flow would improve trout habitat in Little Last Chance Creek.

The present operation of Grizzly Valley Dam favors trout habitat. Releases for March to June (0.51 m^3/s) are very near the optimum for rainbow and brown trout. These releases are often continued into the summer months, which benefits trout habitat in Big Grizzly Creek. In very wet years the scheduled releases are increased to 0.65 m^3/s for several months.

Spawning habitat is very limited at all three study areas. Little Last Chance and Big Grizzly Creeks had small amounts of spawning gravel but none was found at the Middle Fork Feather River study area. Spawning gravel is present in all these streams, but in widely scattered pockets. The flows measured at the study area on Big Grizzly Creek had no weighted usable area for spawning.

CONCLUSIONS AND RECOMMENDATIONS

Revised operation of Lake Davis and Frenchman Reservoir would provide opportunities to increase trout habitat in Big Grizzly Creek and Little Last Chance Creek. The present operation of Lake Davis is favorable for trout habitat, because releases of 0.51 m^3/s are often continued after scheduled reduction to 0.23 m^3/s. Changing the operation schedule to 0.56 m^3/s all year would further increase trout habitat and reduce reservoir spills.

An operation study prepared by the Division of Operation and Maintenance shows that little change would occur in summer lake levels with such a revised schedule (Appendix 4), so there would be little impact on recreation at Lake Davis. Releases would be decreased to 0.42 m^3/s or 0.28 m^3/s during dry years to keep the lake elevation as high as possible.

The Department is seeking purchase of fishing access rights along Big Grizzly Creek below Lake Davis. Guaranteed public access is needed for anglers to take advantage of the improved fishing in Big Grizzly Creek provided by the reservoir releases. The proposal to increase downstream fishery habitat also adds support to the need for improved public access.

Current operating criteria for Frenchman Reservoir are not favorable for trout habitat. Minimum winter releases of 0.06 m^3/s or less are poor for trout habitat. Irregular releases during the summer months also affect trout habitat. Water rights and the contract with the Last Chance Creek Water District fully commit runoff from Frenchman Reservoir and offer little opportunity to improve trout habitat in Little Last Chance Creek. Any increase in winter flows would improve trout habitat. Likewise, whenever possible, summer release fluctuations should be minimized.

Flows in the Middle Fork Feather River near Portola can be increased by higher releases from Lake Davis. Summer releases from Frenchman Reservoir are used for irrigation in Sierra Valley and usually do not reach the outlet of the valley near Portola. Higher summer flows would moderately increase trout habitat in the Middle Fork below Big Grizzly Creek.

ACKNOWLEDGEMENTS

Thanks are due Joan Cherron and Jerry Tittel for the long hours spent collecting, recording, and interpreting data. Joe Nessler and Conrad Lahr were very helpful in scheduling releases needed for study and reporting changes in flow so the field measurements could be made.

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APPENDIX 1

OPERATING CRITERIA FOR FRENCHMAN RESERVOIR [1/]

Operating Criteria 4200

Inflow to the reservoir will be stored and released in accordance with the following criteria. These criteria will be the basis for the project water delivery capability reports that will be issued by the Water Operations Branch of the Division of Operations.

Mandatory Releases. Mandatory flows will enter and leave the reservoir without regulation. Mandatory releases from March 15 through May 31 will include all instantaneous inflows up to the amount that will provide 94.4 second-feet to downstream diversion points. The 94.4 second-feet maximum will include stream accretions between the dam and the diversion points; from June 1 through October 31 all reservoir inflow will be passed through the dam; from October 1 through March 14 mandatory releases will consist of fishery maintenance flows and possible augmentation of stream accretions below the dam to fill Last Chance Reservoir by March 15. The 2 cfs release for fishery maintenance flows from October 1 through March 14 is a maximum and may be reduced to reservoir inflow when that inflow is less than 2 cfs and the reservoir storage is less than 16,000 acre-feet on October 1. Unavoidable spills may be used in meeting any of the above requirements. 4210

Regulated Releases. Inflow other than that required for mandatory releases or unavoidable spills may be stored in the reservoir from November 1 through May 31. Releases from this storage will be made in accordance with any contract signed with the Last Chance Water District. 4220

Contract Water. The criteria for determining the quantity of stored or regulated water available for sale to the contractors will be as follows: 4221

1/ Quoted from Operation and Maintenance Manual for Frenchman Dam, Department of Water Resources, Division of Operation and Maintenance; the manual is not metricized.

Contract Water. (Continued) 4221

1. Usable storage of May 1 will be determined by deducting the minimum pool storage from the total storage on May 1.

2. The usable storage will be further reduced by the amount of evaporation and other reservoir losses estimated to occur during the ensuing season.

3. Daily inflow during the ensuing season will be estimated.

4. Estimated inflow during May in excess of that required for mandatory release will be added to the usable storage minus losses to give the water available for sale.

Contract Water Delivery. Upon notification by the contractors of how much of this available water they wish to have delivered, this quantity will be scheduled to supplement estimated mandatory releases and unavoidable spills, if any, so that the total release will be made on a suitable irrigation schedule. 4222

Initial Filling. During initial filling of the reservoir, one-half of the inflow that is in excess of mandatory releases will be available for regulation and sale, and one-half will be applied to building up the minimum recreational pool. Filling prior to April 15, 1962, will be governed by the Letter Agreement between the State of California and the individual water right holders. This agreement is discussed in Section 2600. 4230

Storage. From November 1 to June 1 all inflow in excess of the releases determined according to the criteria in Section 4210 will be stored when it is physically possible to do so. After June 1 no inflow will be stored unless it is physically impossible to avoid. 4240

No stop logs or other obstructions may be placed across the spillway to increase the reservoir storage.

The reservoir will be operated to maintain a recreation pool with a minimum elevation of 5,560 feet, U.S.G.S. datum. There will be no encroachment into this minimum pool except when it is necessary to do so in order to supply fish release and water rights as specified in Section 2700 of this manual. Contract water will be available only from the storage above the stage of 5,560 feet, except during the initial filling of the reservoir.

APPENDIX 2

RELEASE CRITERIA FOR LAKE DAVIS 1/

Fishery Enhancement Release Schedule

Water Surface Elevation on May 1 (feet)	Release in CFS May 1 - June 15	June 16 - March 15	March 16 - April 30
Above 5,773	18	8	18
5,770 to 5,773	15	5	15
Below 5,770	14	4	14

Water Rights Entitlement Release Schedule

	Max. Annual Entitlement (AF)	Max. Del. Rate (CFS)	Deficiency	Special Provisions
Andrew Valberde	135	None Before 6/15, 2 CFS After	Standard Provision	Del. of 100 AF Before 6/15, 35 AF After
United States of America	800	7 CFS	Standard Provision	Max Carry-over 100 AF to Following Year

1/ Quoted from Operation and Maintenance Manual for Grizzly Valley Dam, Department of Water Resources, Division of Operation and Maintenance; therefore, this appendix is not metricized.

APPENDIX 3

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR RAINBOW TROUT AND BROWN TROUT

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR SPAWNING RAINBOW TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
0.0	0.000–0.168	0.0	0.000–0.099	0	Sand
0.1	0.169–0.190	0.1	0.100–0.114	1.0	Gravel
0.2	0.191–0.206	0.2	0.115–0.129	0	Cobble/Rubble
0.3	0.207–0.221	0.3	0.130–0.145		
0.4	0.222–0.244	0.5	0.146–0.160		
0.5	0.245–0.290	0.7	0.161–0.175		
0.6	0.291–0.328	0.9	0.176–0.190		
0.7	0.329–0.343	1.0	0.191–0.282		
0.8	0.344–0.366	0.9	0.283–0.320		
0.9	0.367–0.411	0.8	0.321–0.350		
1.0	0.412–0.617	0.7	0.351–0.381		
0.9	0.618–0.655	0.6	0.382–0.411		
0.8	0.656–0.678	0.5	0.412–0.442		
0.7	0.679–0.716	0.4	0.443–0.472		
0.6	0.717–0.770	0.3	0.473–0.518		
0.5	0.771–0.823	0.2	0.519–0.602		
0.4	0.824–0.869	0.1	0.603–0.808		
0.3	0.870–0.891	0.0	0.809– ∞		
0.2	0.892–0.914				
0.1	0.915–0.952				
0.0	0.953– ∞				

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR
FRY RAINBOW TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
0.1	0.000–0.023	0.0	0.000–0.084	0	Mud/Clay
0.2	0.024–0.038	0.1	0.085–0.114	0.15	Silt
0.3	0.039–0.053	0.2	0.115–0.137	0.2	Sand
0.6	0.054–0.069	0.5	0.138–0.168	1.0	Gravel
0.9	0.070–0.091	1.0	0.169–0.305	0.3	Cobble-Rubbel
1.0	0.092–0.213	0.9	0.306–0.350	0.07	Boulder
0.9	0.214–0.236	0.8	0.351–0.373	0.02	Bedrock
0.8	0.237–0.282	0.7	0.374–0.389	0	Other
0.7	0.283–0.366	0.6	0.390–0.411		
0.6	0.367–0.450	0.5	0.412–0.442		
0.5	0.451–0.518	0.4	0.443–0.480		
0.4	0.519–0.564	0.3	0.481–0.541		
0.3	0.565–0.610	0.2	0.542–0.640		
0.2	0.611–0.671	0.1	0.641– ∞		
0.1	0.672–0.754				
0.0	0.755– ∞				

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR JUVENILE RAINBOW TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
0.0	0.000-0.038	0.0	0.000-0.129	0	Sand
0.1	0.039-0.053	0.1	0.130-0.152	1.0	Gravel
0.2	0.054-0.069	0.2	0.153-0.175	0.35	Cobble/Rubble
0.3	0.070-0.084	0.3	0.176-0.190	0.1	Boulder
0.4	0.085-0.099	0.4	0.191-0.206	0	Bedrock
0.7	0.100-0.114	0.6	0.207-0.221		
0.9	0.115-0.160	0.8	0.222-0.236		
1.0	0.161-0.457	0.9	0.237-0.259		
0.9	0.458-0.518	1.0	0.260-0.343		
0.8	0.519-0.556	0.9	0.344-0.358		
0.7	0.557-0.602	0.8	0.359-0.381		
0.6	0.603-0.648	0.7	0.382-0.411		
0.5	0.649-0.701	0.6	0.412-0.450		
0.4	0.702-0.739	0.5	0.451-0.503		
0.3	0.740-0.754	0.4	0.504-0.571		
0.2	0.755-0.777	0.3	0.572-0.762		
0.1	0.778-0.991	0.2	0.763-1.082		
0.0	0.992- ∞	0.1	1.083- ∞		

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR
ADULT RAINBOW TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
0.1	0.000-0.023	0.0	0.000-0.046	0	Sand
0.2	0.024-0.053	0.1	0.047-0.183	0.9	Gravel
0.3	0.054-0.099	0.2	0.184-0.320	1.0	Cobble-Rubble
0.4	0.100-0.145	0.3	0.321-0.389	0.9	Boulder
0.5	0.146-0.190	0.4	0.390-0.419	0.25	Bedrock
0.6	0.191-0.229	0.5	0.420-0.442	0	Other
0.7	0.230-0.267	0.7	0.443-0.465		
0.8	0.268-0.290	0.9	0.466-0.495		
0.9	0.291-0.335	1.0	0.496- ∞		
1.0	0.336-0.427				
0.9	0.428-0.480				
0.8	0.481-0.533				
0.7	0.534-0.594				
0.6	0.595-0.640				
0.5	0.641-0.678				
0.4	0.679-0.716				
0.3	0.717-0.754				
0.2	0.755-0.800				
0.1	0.801-0.853				
0.0	0.854- ∞				

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR SPAWNING BROWN TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
0.0	0.000–0.076	0.0	0.000–0.091	0	Sand
0.1	0.077–0.145	0.1	0.092–0.114	1.0	Gravel
0.2	0.146–0.190	0.2	0.115–0.129	0	Cobble/Rubble
0.3	0.191–0.244	0.5	0.130–0.145		
0.4	0.245–0.297	0.8	0.146–0.160		
0.5	0.298–0.335	1.0	0.161–0.251		
0.6	0.336–0.381	0.9	0.252–0.290		
0.7	0.382–0.427	0.8	0.291–0.312		
0.8	0.428–0.450	0.7	0.313–0.328		
0.9	0.451–0.465	0.6	0.329–0.343		
1.0	0.466–0.648	0.5	0.344–0.366		
0.9	0.649–0.693	0.4	0.367–0.411		
0.8	0.694–0.716	0.3	0.412–0.488		
0.7	0.717–0.747	0.2	0.489–0.625		
0.6	0.748–0.770	0.1	0.626–0.815		
0.5	0.771–0.785	0.0	0.816– ∞		
0.4	0.786–0.815				
0.3	0.816–0.869				
0.2	0.870–0.975				
0.1	0.976–1.196				
0.0	1.197– ∞				

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR
FRY BROWN TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
1.0	0.000–0.358	0.0	0.000–0.023	0.19	Organic
0.9	0.359–0.396	0.1	0.024–0.053	0.19	Mud/Clay
0.8	0.397–0.427	0.2	0.054–0.076	0.3	Silt
0.7	0.428–0.457	0.3	0.077–0.107	0.95	Sand
0.6	0.458–0.495	0.5	0.108–0.137	1.0	Gravel
0.5	0.496–0.541	0.7	0.138–0.168	0.88	Cobble/Rubble
0.4	0.542–0.587	0.9	0.169–0.213	0.2	Boulder
0.3	0.588–0.632	1.0	0.214–0.587	0	Bedrock
0.2	0.633–0.701	0.9	0.588–0.648	0	Other
0.1	0.702–0.823	0.8	0.649–0.686		
0.0	0.824– ∞	0.7	0.687–0.716		
		0.6	0.717–0.762		
		0.5	0.763–0.838		
		0.4	0.839–0.937		
		0.3	0.938–1.044		
		0.2	1.045–1.173		
		0.1	1.174–1.387		
		0.0	1.388– ∞		

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR
JUVENILE BROWN TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
1.0	0.000–0.137	0.0	0.000–0.015		
0.9	0.138–0.190	0.1	0.016–0.053	0.2	Organic
0.8	0.191–0.236	0.2	0.054–0.084	0.2	Mud/Clay
0.7	0.237–0.312	0.3	0.085–0.107	0.25	Silt
0.6	0.313–0.419	0.6	0.108–0.137	0.7	Sand
0.5	0.420–0.510	0.9	0.138–0.183	0.85	Gravel
0.4	0.511–0.579	1.0	0.184–0.876	1.0	Cobble/Rubble
0.3	0.580–0.640	0.9	0.877–0.922	0.12	Boulder
0.2	0.641–0.792	0.8	0.923–0.937	0	Bedrock
0.1	0.793–0.960	0.7	0.938–0.952		
0.0	0.961–∞	0.6	0.953–0.975		
		0.5	0.976–1.013		
		0.4	1.014–1.074		
		0.3	1.075–1.227		
		0.2	1.228–1.417		
		0.1	1.418–1.646		
		0.0	1.647–∞		

*USFWS, 1978

CRITERIA AND PROBABILITY-OF-USE FACTORS FOR
ADULT BROWN TROUT*

Velocity		Depth		Substrate	
Probability-of-Use Factor	Velocity Range (m/s)	Probability-of-Use Factor	Depth Range (m)	Probability-of-Use Factor	Substrate Type
1.0	0.000–0.274	0.0	0.000–0.244	0.3	Organic
0.9	0.275–0.312	0.1	0.245–0.267	0.3	Mud/Clay
0.8	0.313–0.343	0.3	0.268–0.282	0.4	Silt
0.7	0.344–0.366	0.5	0.283–0.305	0.9	Sand
0.6	0.367–0.442	0.6	0.306–0.442	1.0	Gravel
0.5	0.443–0.541	0.7	0.443–0.610	0.9	Cobble/Rubble
0.4	0.542–0.610	0.8	0.611–0.678	0.16	Boulder
0.3	0.611–0.686	0.9	0.679–0.724	0	Bedrock
0.2	0.687–0.861	1.0	0.725–∞		
0.1	0.862–1.410				
0.0	1.411–∞				

*USFWS, 1978

APPENDIX 4

SUMMARY OF OPERATION STUDY FOR LAKE DAVIS 1/

Water Surface Elevation Forecast for December 1 2/	Streamflow Release
Above Elevation 5,771 feet	20 cfs
Elevation 5,771 feet to 5,768 feet	15 cfs
Below Elevation 5,768 feet	10 cfs

The operation study assumed a reservoir elevation of 5,774 feet on July 1, 1967, used the existing record of inflow, computed evaporation, and releases to Plumas County at approximately 310 acre-feet per year with the following results.

Year	Release	Revised Operation Minimum Lake Elevation	Actual Historic Lake Elevation
1967	20 cfs	5,771 ft	5,765 ft
1968	20 cfs	5,770 ft	5,767 ft
1969	20 cfs	5,772 ft	5,772 ft
1970	20 cfs	5,772 ft	5,772 ft
1971	20 cfs	5,772 ft	5,773 ft
1972	20 cfs	5,771 ft	5,771 ft
1973	20 cfs	5,771 ft	5,771 ft
1974	20 cfs	5,771 ft	5,772 ft
1975	20 cfs	5,772 ft	5,772 ft
1976	15 cfs	5,767 ft	5,768 ft
1977	10 cfs	5,764 ft	5,759 ft
1978	15 cfs	5,769 ft	5,767 ft
1979	10 cfs	5,769 ft	5,764 ft
1980	20 cfs	5,771 ft	5,770 ft

1/ Modified from memorandum from Joe Nessler to Lee Carter and Larry Mullnix, dated October 10, 1981; therefore this appendix is not metricized.

2/ First forecast and release adjustment to be made on March 1 with updates through May 1.

Slight deviation from these criteria occurred based on the assumption that forecasts would be accurate enough to predict minimum lake elevation within plus or minus 1 foot.

During the 14-year period the release would be 20 cfs for 10 years, 15 cfs for 2 years, and 10 cfs for 2 years. The new boat ramp is usable to a minimum water surface elevation of 5,767 feet. During the study period, the ramp would be unusable for about 4 months during the summer and fall of 1977. The minimum lake elevation for the entire study period, 5,764 feet, would occur in December 1977. This is 4 feet above the center of the upper 36-inch valve on the intake tower.

During the actual historic operation, the reservoir was below elevation 5,767 feet for nearly 10 months (July 15, 1977 to April 10, 1978) and reached a minimum elevation of 5,759 feet in December 1977. Thus, the proposed operation would slightly improve low water conditions.

CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C)+32	(°F−32)/1.8